

PATENT COOPERATION TREATY

WO 01/04661
PCT/GB00/02697

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

From the INTERNATIONAL BUREAU

To:
WANG, William, L.
Schlumberger Cambridge Research
Limited
High Cross
Maddingley Road
Cambridge CB3 0EL
ROYAUME-UNI

57.0320 WO PCT
X

Date of mailing (day/month/year) 18 January 2001 (18.01.01)		
Applicant's or agent's file reference 57.0320WOPCT		IMPORTANT NOTICE
International application No. PCT/GB00/02697	International filing date (day/month/year) 13 July 2000 (13.07.00)	Priority date (day/month/year) 14 July 1999 (14.07.99)
Applicant SCHLUMBERGER HOLDINGS LIMITED et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
AG,AU,BZ,DZ,KP,KR,MZ,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CN,CR,CU,CZ,DE,DK,DM,EA,EE,EP,ES,FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,ZA,ZW
The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).
3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 18 January 2001 (18.01.01) under No. WO 01/04661

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

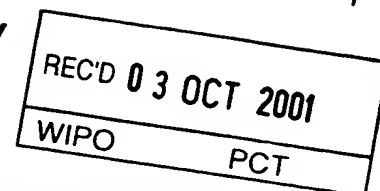
For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

PATENTS
29 JAN 2001
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WLM

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 57.0320 WO PCT	<div style="display: flex; justify-content: space-between;"> <div> FOR FURTHER ACTION </div> <div> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) </div> </div>	
International application No. PCT/GB00/02697	International filing date (day/month/year) 13/07/2000	Priority date (day/month/year) 14/07/1999
International Patent Classification (IPC) or national classification and IPC E21B47/12		
Applicant SCHLUMBERGER HOLDINGS LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 8 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

I ☒ Basis of the report

II ☐ Priority

III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

IV ☐ Lack of unity of invention

V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

VI ☒ Certain documents cited

VII ☒ Certain defects in the international application

VIII ☒ Certain observations on the international application

Date of submission of the demand 13/01/2001	Date of completion of this report 01.10.2001
Name and mailing address of the international preliminary examining authority: <div style="display: flex; align-items: center;"> <div> European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465 </div> </div>	Authorized officer Str mmen, H Telephone No. +49 89 2399 7345



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/02697

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-11 as originally filed

Claims, No.:

1-14 as originally filed

Drawings, sheets:

1/2-2/2 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/02697

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 14.

because:

☒ the said international application, or the said claims Nos. 14 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N) Yes: Claims 3-5, 6-8, 10,12

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	No:	Claims	1-2, 9, 13
Inventive step (IS)	Yes:	Claims	4-5
	No:	Claims	1-3, 6-13
Industrial applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

2. Citations and explanations
see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Reference is made to the following documents:

D1: GB-A-1 549 307

D2: WO 99 66172 A

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

III-1 Claim 14 does not specify explicitly and univocally any technical feature, and can therefore not be examined. Furthermore, said claim contains references to the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

V-1 Claim 1 is not clear, see section VIII-1 of this written opinion. D1, which is considered the closest prior art, discloses the subject-matter of claim 1, as far as it can be understood, as follows:

A sensing apparatus (fig. 6) comprising a housing (38) and sensing means (inside case 34, see p. 3, l. 50-54), wherein the housing (38) comprises [contains] a plurality of separable elements (33) to which data acquired by the sensing means is transferred (p. 3, left col., l. 61-64), and which are releasable, after data transfer, from the housing (p. 3, l. 66-78).

The subject-matter of claim 1 is therefore not new contrary to the provisions of Article 33(2) PCT.

V-2 Claim 2 is not new (Article 33(2) PCT). See D1, page 5, l. 46-58.

V-3 In order to prevent destructive turbulence in the upper end of the groove 32

(D1, fig. 6), D1 further suggests to arrange openings in the lower end of the plate covering groove 32 (p. 3, l. 102-105). In the process of solving this problem it would be obvious for the skilled man to alternatively provide a port in the upper end which could be selectively opened and closed. Claim 3 does therefore not involve an inventive step (Article 33(3) PCT)

V-4 Claims 4 and 5 relate to the problem of protecting the separable elements and sealing the electrical contact area prior to release of the separable element.

D1 teaches that each element should be covered by a "protective envelope" during the journey through the borehole, see p. 6, l. 7-11. From p. 2, l. 1-5 it can further be understood that some kind of non-conductive and protective mass of material encloses the element. It is however not made obvious to provide for a sealable aperture through which data can be communicated. The subject-matter of claims 4-5 meets therefore the requirements of Article 33(2) and (3) PCT.

V-5 Claims 6 and 7 do not involve an inventive step (Article 33(3) PCT) as it would be obvious for the skilled man to consider a streamlined form for the casing when solving the underlying problem.

V-6 Claim 8 does not involve an inventive step (Article 33(3) PCT) as it is standard practice to produce housings and cover plates as well as protective enclosures of both metal and plastics materials. See D1, "cover plate 38" and p. 6, l. 7-11.

V-7 Claim 9 is not new (Article 33(2) PCT). See D1, page 5, l. 1-6.

V-8 When read as depending from claim 1, claims 10 and 11 do not involve an inventive step (Article 33(3) PCT). Whether the length, width or diameter of the separable elements is to be determined, the skilled man will certainly find it obvious to arrive at a result within the ranges as given in said claims. Especially when studying the circuit boards as shown in D1, fig. 1 together with the information given in the diagram in fig. 9.

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/02697

- V-9 For any type of data transfer, serial or parallel, it is standard practice to code and encrypt data after a suitable protocol. Claim 12 can therefore not involve an inventive step (Article 33(3) PCT).
- V-10 Independent method claim 13 relate effectively to the same subject-matter as claim 1. Claim 13 does therefore also not meet the requirements of Article 33(2) PCT.

Re Item VI

Certain documents cited

- VI-1 Certain published documents (Rule 70.10)

Document No.:	Publication date:	Filing date:	Priority date:
WO99/66172	23.12.1999	09.06.1999	12.06.1998

D2 was filed before the filing date of the present application but published after said date, whereby the document is not part of the prior art as defined in Rule 64.1 PCT. The attention of the applicant is however drawn to the fact that said document or a document corresponding to it, could be considered as part of the prior art, at least as far as novelty is concerned, in a possible national or regional phase.

Re Item VII

Certain defects in the international application

- VII-1 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
- VII-2 Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in D1 is not mentioned in the description, nor is this document identified therein.
- VII-3 According to the requirements of Rule 11.13(m) PCT the same feature shall be denoted by the same reference sign throughout the application. This

requirement is not met in view of the use of "separable elements" as used in the claims and "releasable elements" as primarily used in the main parts of the description. See page 6.

- VII-4 According to the requirements of Rule 11.13(m) PCT the same feature shall be denoted by the same reference sign throughout the application. This requirement is not met in view of the use of "tool 16" and "sensing apparatus 16". See page 6.
- VII-5 According to the requirements of Rule 11.13(l) reference signs not appearing in the description shall not appear in the drawings, and vice versa. This requirement is not met in view of the reference sign "68" on page 8.

Re Item VIII

Certain observations on the international application

- VIII-1 The present set of claims are identical to the claims presented in PCT application GB00/02686. The attention of the applicant is therefore drawn to the fact that, in a possible national phase, the applicant may be required to choose which one of the applications should proceed to grant. See also the PCT Guidelines PCT/GL/3 IV-6.3.
- VIII-2 The term "comprises" in the third line of claim 1 is read as "contains".
- VIII-3 The problem that the apparatus of claim 1 aims to solve, is to transfer information from a downhole tool to the surface. It is therefore essential that the "separable elements", according to claim 1, are releasable when the apparatus is still downhole. Said feature is missing in claims 1 and 13.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

WANG, William L.
SCHLUMBERGER CAMBRIDGE RESEARCH
LIMITED
High Cross
Maddingley Road
Cambridge CB3 0EL
GRANDE BRETAGNE

PATENTS

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NOTIFICATION OF TRANSMITTAL OF
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EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing
(day/month/year)

01.10.2001

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IMPORTANT NOTIFICATION

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13/07/2000

Priority date (day/month/year)
14/07/1999

Applicant

SCHLUMBERGER HOLDINGS LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

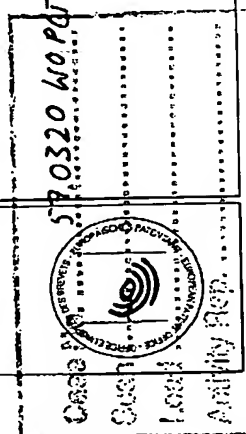
Name and mailing address of the IPEA/

 European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Goenechea Olmos, A

Tel. +49 89 2399-2664



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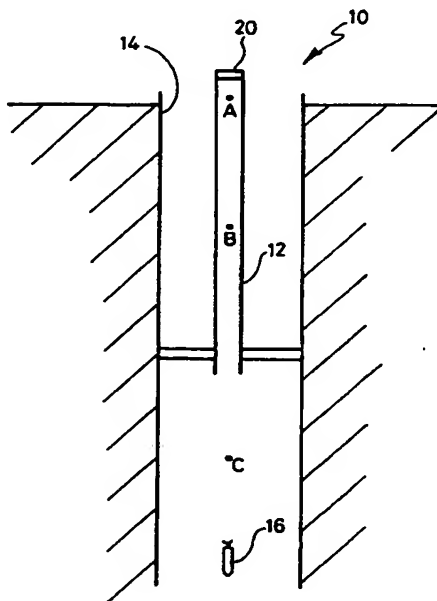
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9916350.3 14 July 1999 (14.07.1999) **GB**
- (71) Applicant (for all designated States except CA, FR, NO, US): **SCHLUMBERGER HOLDINGS LIMITED** [—/—]; P.O. Box 71, Craigmuir Chambers, Road Town, Tortola (VG).
- (71) Applicant (for CA only): **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 24th Floor, Monenco Place, 801 6th Avenue, S.W., Calgary, Alberta T2P 3W2 (CA).
- (71) Applicant (for FR only): **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42, rue Saint-Dominique, F-75007 Paris (FR).
- (72) Inventors; and
(75) Inventors/Applicants (for US only): **SHEPPARD, Michael, Charles** [GB/GB]; 6 Whitmore Way, Waterbeach, Cambridgeshire CB5 9HS (GB) **ZIMMERMAN, Thomas, Harvey** [US/US]; 15922 Clearcrest, Houston, TX 77059 (US).
- (74) Agent: **WANG, William, L.**; Schlumberger Cambridge Research Limited, High Cross, Madingley Road, Cambridge CB3 0EL (GB).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

[Continued on next page]

(54) Title: **DOWNHOLE SENSING APPARATUS WITH SEPARABLE ELEMENTS**



(57) Abstract: A sensing apparatus (16) is provided for use downhole, comprising a housing (22) and sensing means (52, 54, 56, 58) with the housing (22) containing a plurality of separable elements (64) to which data acquired by the sensing means (52, 54, 56, 58) is transferred. The separable elements (64) are releasable from the housing to convey the acquired data to surface. The separable elements have a spherical outer casing (72) of around 1 to 10 cm diameter which surrounds a memory chip (74). The casing (72) has a sealable aperture (76) so that electrical connection to the chip (74) can be established within the housing.

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Downhole Sensing Apparatus With Separable Elements

FIELD OF THE INVENTION:

The invention relates to a sensing apparatus
5 particularly suitable for use downhole within oil and
gas wells.

BACKGROUND OF THE INVENTION:

Gathering of information relating to a well
10 is possible by lowering a logging tool on a wireline
into a well. The logging tool acquires data relating
to the well characteristics, such as fluid velocity and
temperature, and typically transmits the logged data to
surface by telemetry along the wireline. However
15 logging tools on wirelines often get caught within the
well, leading to problems of acquiring data at desired
positions and also retrieval of the tool.

Self-powered robotic logging devices have
20 been developed to avoid the need for use of a wireline.
It is relatively easy to get a self-powered robotic
device to the bottom of a well because downwards travel
of the device involves moving from smaller diameter
production tubing to larger diameters at the bottom of
25 the well. However difficulties occur in retrieving
such devices because the return journey to the surface
involves locating, and passage through, the smaller
diameter opening.

30 It is one aim of the present invention to
provide a sensing apparatus which at least in part

overcomes the existing difficulties with robotic logging devices.

5 SUMMARY OF THE INVENTION:

 In accordance with one aspect of the invention, there is provided sensing apparatus comprising a housing and sensing means, characterised
10 in that the housing contains a plurality of separable elements to which data acquired by the sensing means is transferred, and which are releasable, after data transfer, from the housing.

15 The separable elements act as passive receptors for data acquired from the sensing means, and in this way, an autonomously powered device can be sent downhole and left in place while data is transferred to the surface over time by sending the separable elements
20 back to the surface, so extending the useful lifetime of the sensing apparatus.

 The sensing means may include or be connected to electronic memory means which temporarily stores the
25 acquired data. The stored data can be downloaded to a further memory device in a separable element when required.

 Preferably the sensing apparatus comprises
30 actuatable port means, openable to release the separable elements.

Preferably the separable elements each comprise a rigid casing, with a sealable aperture, the casing surrounding data storage means, such as a memory chip, in which the acquired data is stored for transfer to the surface. The aperture allows a connection to be made to the data storage means therein so that data can be written thereto. Closure and sealing of the aperture permits watertight sealing of the element to protect the memory chip from wellbore fluids once the separable element is released.

Preferably the aperture is surrounded by a sealing material, typically made of thermosetting plastics material, which can be heat treated within the housing so as to provide a fluid-tight seal which is continuous with the casing surface. This improves the robustness of the separable element.

The separable elements are preferably spherical so as to reduce the likelihood that they will snag on protrusions within the interior of the well. Thus typically each separable element will comprise two hollow metal hemi-spheres, joined by a plastics seal to form a sphere.

Preferably the separable elements are also configured to be either neutrally buoyant, or buoyant, in relation to well fluids, so that they are easily carried to surface.

Generally the separable elements have a diameter in the range of 1 to 10cm, and more preferably in the range 1 to 5cm, so that they can easily transfer from downhole large diameter sections to smaller diameter tubing nearer the surface. Typically a large number of separable elements are contained in the housing, of the order of 100-500 elements.

The housing of the sensing apparatus and the casings of the separable elements may be formed from plastics material or metal.

The invention also lies in the provision of separable elements in a downhole sensing apparatus as aforesaid.

In accordance with another aspect of the invention, there is also provided a method of acquiring data from downhole, comprising placing downhole a sensing apparatus containing a number of separable elements and releasing the elements to carry acquired data to the surface as required.

BRIEF DESCRIPTION OF THE DRAWINGS:

The invention will now be described by way of example, and with reference to, the accompanying drawings in which:

Figure 1 shows a schematic diagram of a sensing apparatus according to the present invention during travel downhole;

5 Figure 2 shows a cross-section of the sensing apparatus; and

Figure 3 shows a section along line III-III of Figure 2.

10

DETAILED DESCRIPTION OF THE INVENTION:

In Figure 1, a completed well 10 is shown, with production tubing 12 cemented into position centrally within a borehole 14. The production tubing 12 is capped at surface and an autonomous sensing apparatus or tool 16, which has been transferred through a cap 20 to travel downhole under its own power, is shown passing down the wellbore 14 from position A to position B, and thence to beyond position C where it emerges into the completion.

As the tool 16 passes downhole, data is either acquired continuously by the tool 16 or acquired at fixed depths along the wellbore 14, with the tool 16 measuring various characteristics including pressure, temperature, flow rate and chemical species. These measurements are referenced to the position in the completion either by counting casing collars and using existing knowledge of the location of perforation sites within the walls of the completion, or by integrating

the velocity of the tool as derived from on-board sensors.

5 The velocity of the tool 16 is typically sensed by including a pair of sonic source/sensor packages or a pair of infra red source/sensor packages to sample the borehole wall and configure such that cross-correlation of the source/receiver pair will provide velocity of the tool.

10

 The sensing apparatus 16 is shown in cross-section in Figure 2. This robotic device has a body 22 with a total length of around 2.1m and is generally comprised of three sections, a rear 24, a front 26 and
15 a middle section 30. The middle section 30 is a hollow cylindrical metal casing of diameter 0.114m which contains and surrounds components carried by the device 16. Attached to each end of the middle section 30 are respective cone sections 32, 34 which are truncated
20 with a hemi-spherical surface to improve the aerodynamic structure of the device.

 The first cone 32 forms a front nose of the device 16, with the second cone 34 attached to the rear
25 of the casing carrying a propeller 36. To strengthen the device 16, an internal carbon fibre wall 40 formed as a hollow cylinder around 7mm wall thickness is inserted into the middle section 30 to improve rigidity and robustness of the device 16, and also to protect
30 components contained within the middle section when downhole. The carbon fibre wall 40 thus encases active

sensing and data storage components which are contained within the device 16, and the wall 40 is generally provided with a number of individual compartments so that different parts of the middle section 30 can be
5 sealed with respect to other compartments.

Towards the rear end of the middle section 30, a motor 42 is provided which is attached to the propeller 36 carried on the second cone 34. The motor
10 42 and other electrical components within the device are powered by three batteries 44 arranged in series, and the motor 42 turns the propeller 36 to drive the device 16 downhole. Where the motor 42 and propeller 36 are attached, shaft seals 46 are used to ensure that
15 the rear end of the middle section is sealed against external fluid.

A ballast holder 50 is placed centrally of the middle section 30, and an appropriate amount of
20 ballast introduced into this container so that the tool 16 is neutrally buoyant, i.e. it neither sinks nor rises within the fluid downhole. This ensures that the tool 16 can be powered through the produced fluids by the motor 42 and associated propeller 36. A variety of
25 sensors 52, 54, 56, 58 are included within the body of the device 16 to sense various parameters downhole including pressure, temperature, flow rate, chemical species, magnetic flux and fluid composition. The data
provided by the sensors 52, 54, 56, 58 is stored in
30 data acquisition and control board 62 which, like the motor 42, is powered by the three batteries 44.

Towards the front end of the middle section, a large number of releasable elements 64, or memory fish, are contained in a front compartment 68 which is sealed from the remainder of the device. The compartment need not be sealed hermetically. The releasable elements 64 are carried on and detachably connected to a bus 66 which is in electrical communication with the data acquisition and control board 62. The front compartment 68 is provided with a flap 70 in its external wall, which whilst normally closed, opens to allow release of selected fish in response to a command from the control board 62. The control board 62 is pre-programmed at surface before the device 16 goes downhole with a program which instructs release of the elements 64 in a chosen manner, typically to release a small number of fish at spaced apart intervals of time over a few years.

Each fish 64 comprises a hollow sphere 72 of around 3 to 5cm diameter made substantially of metal and which encases a memory chip 74 to which data can be downloaded via bus 66 from the data acquisition and control board 62. The sphere 72 has an aperture 76 surrounded by heat-sealable material, such as thermosetting plastics material, so that the fish is a completely sealed device. Electrodes 80 on the bus 66 communicate with the memory chip 74 of each fish 64 either inductively or by any other indirect means such as infra-red, or by direct contact through electrical pin conductors attached to the electrodes 80 protruding

into the sphere through the aperture as shown in Figure 3 so as to establish an electrical connection with the chip. Additionally, the data can be encrypted prior to being transferred to the fish. For example, the encryption could be carried out on data acquisition and control board 62, and the encrypted data could be transmitted to memory chips 74 as described.

When a fish is ready for release, it is mechanically raised from the location where it mates with the electrodes 80 so as to separate it from the electrodes on the bus. The opening where the electrodes connected with the chip is sealed by use of a heating element on the sealable material so as to form a substantially smooth water-tight sphere, and then the fish is released. The smooth sealed sphere is robust and resistant to ingress of fluid.

The fish 64 are essentially chips embedded in low density plastics material and can be as small as 1cm², or less, and larger if necessary.

The robotic device 16 can carry up to hundreds of small memory fish 64, which are either neutrally buoyant or partially buoyant and after each set of measurements instructed via the control board 62, the board downloads the collected data to a chosen number of fish 64, and then instructs separation of the selected fish from the bus 66, sealing of the spheres 74 ready for release, and then opening of flap 70 to release the spheres 74. The fish released into the

fluid flowing in the well are swept upwards and are then retrieved at surface. Retrieval of the fish at surface can be assisted by selecting the size and shape of the plastics body 72 of the fish. Typically the
5 same data is written to more than one fish so that the chances of retrieval of the data are maximised. If the data in the fish had been encrypted, the data will then be decrypted after retrieval.

10 Before release of the memory fish 64 into the flow, the tool 16 is programmed to send an acoustic signal by using a transducer, the acoustic signal travelling to surface either via the fluid or the tubulars, so as to alert crew at surface that the
15 release is about to take place and that steps should be taken to retrieve the memory fish. Alternatively the fish may be released at a pre-determined time.

By using the memory fish 64, a robotic
20 production logging device which has been sent to the bottom of a well can lie within the well over a period of time whilst still providing measurements that can be sent to surface via the fish. By providing a large number of memory fish, typically 300-500, within the
25 sensing apparatus and releasing these at selected intervals, the well can be monitored over, for example, 3 to 5 years.

With a robotic logging device, it is much
30 easier to send the device to the bottom of a well than it is to get it to travel back to surface. This is

largely because of the geometry of the tubulars used to encase the internal wall of the well structure as when the robotic device travels from position A to position C, for example, the device moves from smaller diameter tubes of the production tubing to larger tubes of the completion. For the robotic device to travel back to surface, it must travel from a larger diameter tube into a smaller opening, which involves difficulties with locating and entering the smaller tubing. The present invention allows the logging device to remain downhole, whilst still permitting logged data to reach the surface by using the small passive data receptors to carry data to surface by being carried up within the fluid to the surface.

15

The tool can thus sample the well over depth and over periods of time to provide information about the evolution of the downhole flow and fluid character, both of a chemical and physical nature. The device provides a simple production logging tool which avoids well intervention and ensures that wells can be logged cheaply when a convention approach would be too costly.

The sensing apparatus does not necessarily need to be an autonomously powered device, but could be provided either on wireline or even within the casing used to complete the well.

While preferred embodiments of the invention have been described, the descriptions are merely illustrative and are not intended to limit the present invention.

CLAIMS

What is claimed is:

- 5 1. A sensing apparatus comprising a housing
and sensing means, characterised in that the housing
comprises a plurality of separable elements to which
data acquired by the sensing means is transferred, and
which are releasable, after data transfer, from the
10 housing.
2. A sensing apparatus according to claim 1,
wherein the sensing means includes or is connected to
electronic memory means which temporarily stores the
15 acquired data.
3. A sensing apparatus according to claim 1
or claim 2, wherein the sensing apparatus further
comprises an actuatable port means, openable to release
20 the separable elements.
4. A sensing apparatus according to any of
the preceding claims, wherein the separable elements
each comprise a rigid casing with a sealable aperture,
25 the casing surrounding data storage means in which the
acquired data is stored for transfer to the surface.
5. A sensing apparatus according to claim 4,
wherein the sealable aperture is formed by an aperture
30 surrounded by a sealing material, with the sealing
material being heat treatable within the housing so as

to provide a fluid-tight seal which is continuous with the casing surface.

6. A sensing apparatus according to any of
5 the preceding claims, wherein the separable elements are spherical.

7. A sensing apparatus according to claim 6,
wherein each separable element comprises two hollow
10 metal hemi-spheres, joined by a plastics seal to form a sphere.

8. A sensing apparatus according to any of
the preceding claims, wherein the housing of the
15 sensing apparatus and casings of the separable elements are formed from plastics material or metal.

9. A sensing apparatus according to any of
the preceding claims, wherein the separable elements
20 are configured to be either neutrally buoyant or buoyant, in relation to well fluids.

10. A sensing apparatus according to any of
the preceding claims, wherein the separable elements
25 have a diameter in the range of 1 to 10cm.

11. A sensing apparatus according to any of
the claims 1 to 9, wherein the separable elements have
a diameter in the range 1 to 5cm.

30

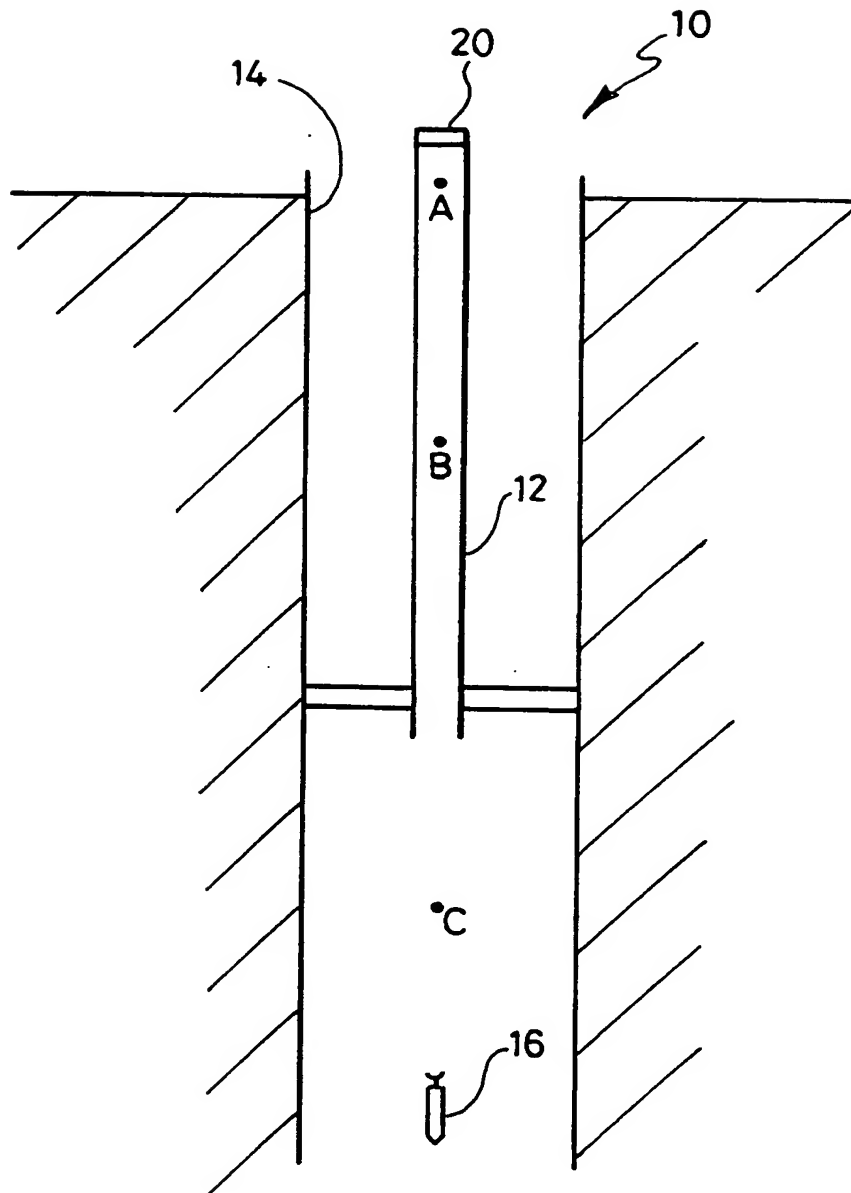
12. A sensing apparatus according to any of the claims 1 to 11, wherein the data is encrypted prior to transfer to the separable elements.

5 13. A method of acquiring data from downhole, comprising placing downhole a sensing apparatus containing a number of separable elements and releasing the elements to carry acquired data to the surface as required.

10

14. Apparatus and method substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

1 / 2

*Fig. 1*

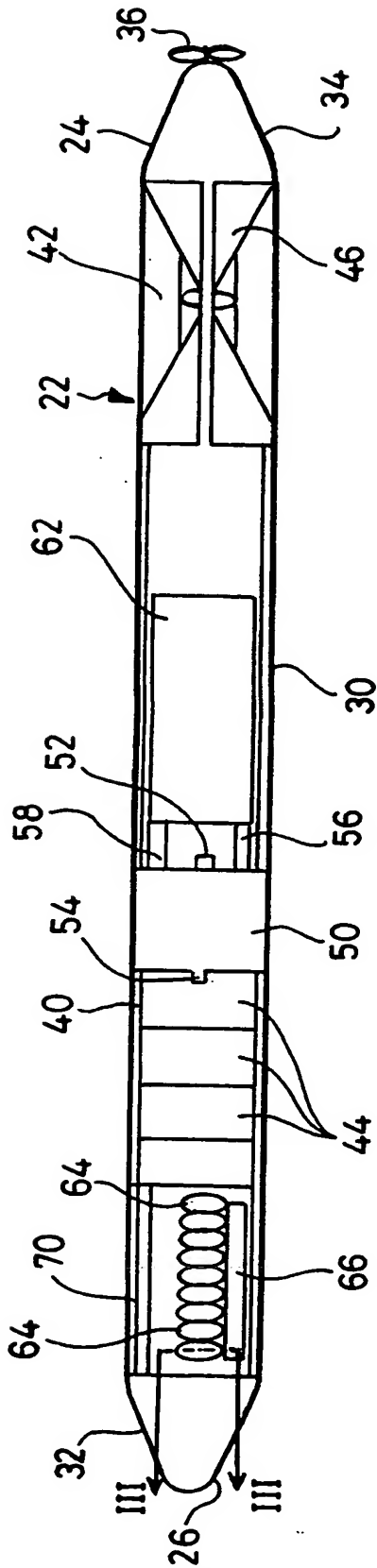


Fig. 2

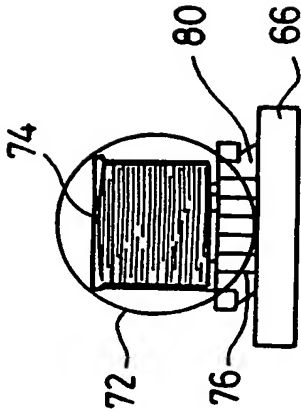


Fig. 3

PATENT COOPERATION TREATY

TRANSMISSION	12 DEC 00
Priority	12.10.00
Date	12.10.00
Inventor	12.10.00

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
**SCHLUMBERGER CAMBRIDGE RESEARCH
 LIMITED**
 Attn. WANG, William L.
 High Cross
 Madingley Road
 Cambridge CB3 0EL
 UNITED KINGDOM

Date of mailing (day/month/year)	12/10/2000
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Applicant's or agent's file reference 57.0320WOPCT	FOR FURTHER ACTION See paragraphs 1 and 4 below
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International application No. PCT/GB 00/ 02697	International filing date (day/month/year)	13/07/2000
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Applicant
SCHLUMBERGER HOLDINGS LIMITED

1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
 34, chemin des Colombettes
 1211 Geneva 20, Switzerland
 Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016

Authorized officer
Jeanne Bauer

PATENTS

DATE RECEIVED	12 OCT 2000
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7222 WLW

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

- (i) the claim is unchanged;
- (ii) the claim is cancelled;
- (iii) the claim is new;
- (iv) the claim replaces one or more claims as filed;
- (v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."
2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."
3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."
4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international application is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 57.0320W0PCT	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/02697	International filing date (day/month/year) 13/07/2000	(Earliest) Priority Date (day/month/year) 14/07/1999
Applicant SCHLUMBERGER HOLDINGS LIMITED		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

2



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.



None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/02697

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 E21B47/12 G 01/00 G01D9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B G01V B63G B63B G01W G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 549 307 A (SHELL INT RESEARCH) 1 August 1979 (1979-08-01) the whole document	1,8,9, 13,14
Y		3,6,7, 10,11
A		2,4
P,Y	WO 99 66172 A (SHELL CANADA LTD ;SHELL INT RESEARCH (NL)) 23 December 1999 (1999-12-23) the whole document	3,6,7, 10,11
A		1,13

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

4 October 2000

Date of mailing of the international search report

12/10/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Chapple, I

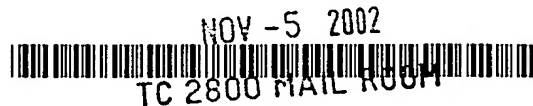
INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/02697

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 1549307	A	01-08-1979	CA 1105617	A	21-07-1981
WO 9966172	A	23-12-1999	AU 4511799	A	05-01-2000

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
18 January 2001 (18.01.2001)

PCT

(10) International Publication Number
WO 01/004661 A3(51) International Patent Classification⁷: **E21B 47/12,**
G01V 11/00, G01D 9/00**Michael, Charles** [GB/GB]; 6 Whitmore Way, Water-
beach, Cambridgeshire CB5 9HS (GB). **ZIMMERMAN,**
Thomas, Harvey [US/US]; 15922 Clearcrest, Houston,
TX 77059 (US).

(21) International Application Number: PCT/GB00/02697

(22) International Filing Date: 13 July 2000 (13.07.2000)

(74) Agent: **WANG, William, L.**; Schlumberger Cambridge
Research Limited, High Cross, Madingley Road, Cam-
bridge CB3 0EL (GB).

(25) Filing Language: English

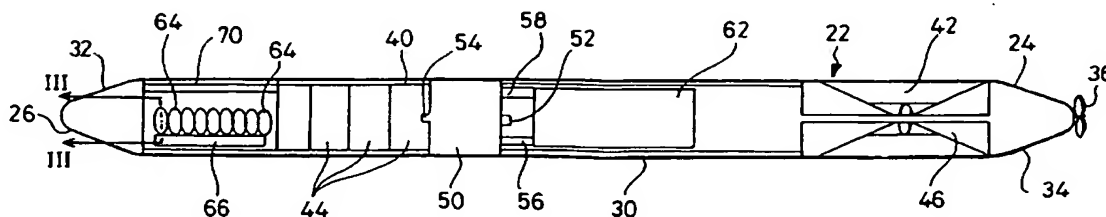
(26) Publication Language: English

(30) Priority Data:
9916350.3 14 July 1999 (14.07.1999) GB(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ,
DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR,
HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,
LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ,
NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM,
TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.(71) Applicant (*for all designated States except CA, FR,*
NO, US): **SCHLUMBERGER HOLDINGS LIMITED**
[—/—]; P.O. Box 71, Craigmuir Chambers, Road Town,
Tortola (VG).(84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG,
CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).(71) Applicant (*for CA only*): **SCHLUMBERGER CANADA**
LIMITED [CA/CA]; 24th Floor, Monenco Place, 801 6th
Avenue, S.W., Calgary, Alberta T2P 3W2 (CA).(71) Applicant (*for FR only*): **SERVICES PETROLIERS**
SCHLUMBERGER [FR/FR]; 42, rue Saint-Dominique,
F-75007 Paris (FR).Published:
— with international search report(71) Applicant (*for NO only*): **SCHLUMBERGER TECH-**
NOLOGY B.V. [NL/NL]; Parkstraat 83-89, NL-2514 JG
The Hague (NL).(88) Date of publication of the international search report:
3 October 2002

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **SHEPPARD,**For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: DOWNHOLE SENSING APPARATUS WITH SEPARABLE ELEMENTS



(57) Abstract: A sensing apparatus (16) is provided for use downhole, comprising a housing (22) and sensing means (52, 54, 56, 58) with the housing (22) containing a plurality of separable elements (64) to which data acquired by the sensing means (52, 54, 56, 58) is transferred. The separable elements (64) are releasable from the housing to convey the acquired data to surface. The separable elements have a spherical outer casing (72) of around 1 to 10 cm diameter which surrounds a memory chip (74). The casing (72) has a sealable aperture (76) so that electrical connection to the chip (74) can be established within the housing.

WO 01/004661 A3